The Carbon Budget of Utah's Forests

What is the carbon sink of Utah's forest land?

Dan Richter

Teaching soils and forest ecology at Duke University & University of Michigan

Throughout career, scientific research on carbon

Motivated by interdisciplinary science,
such as the Utah carbon sink:
A question that involves biology, chemistry, physics, ecology, economics, society, & history

A Tip of the Iceberg Problem:

Forest carbon, a topic of active research

The forest report touches on big issues with highlights of big issues here

Acknowledgements

- To Utah's USFS FIA field-teams & data analysts for over 60 years

- To CCS for making Utah's first state-wide estimates of the Utah forest sink

Why is the land important to carbon?

Some landscapes carbon sources:
deforested tropical forests

Others landscapes are carbon sinks:
regrowing temperate zone forests

Globally, sources exceed sinks, but
both are comparable to industrial emissions!

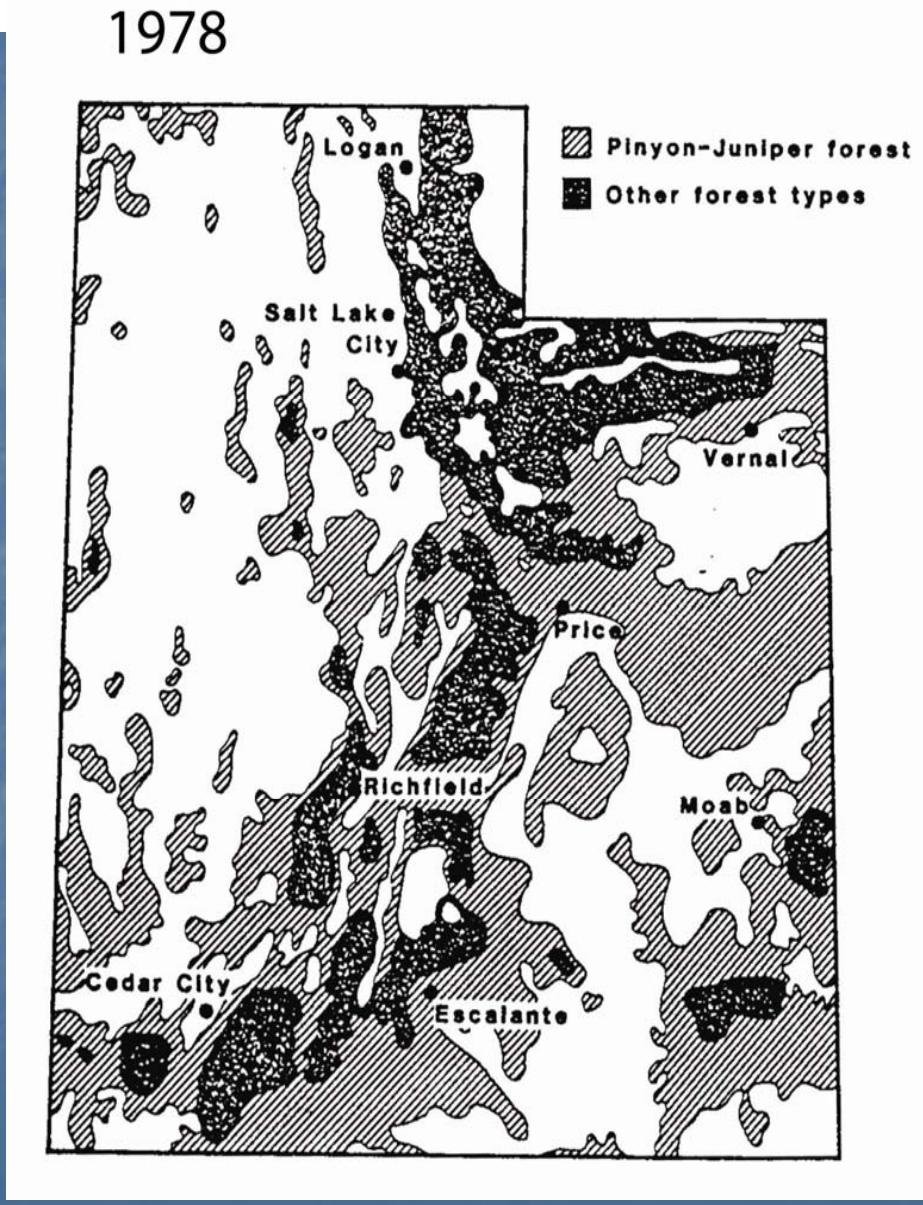
At the risk of getting ahead of the story,

ecologists & foresters see Utah landscapes as carbon sink

Due to a history of land use, forests are increasing in area & in woody biomass

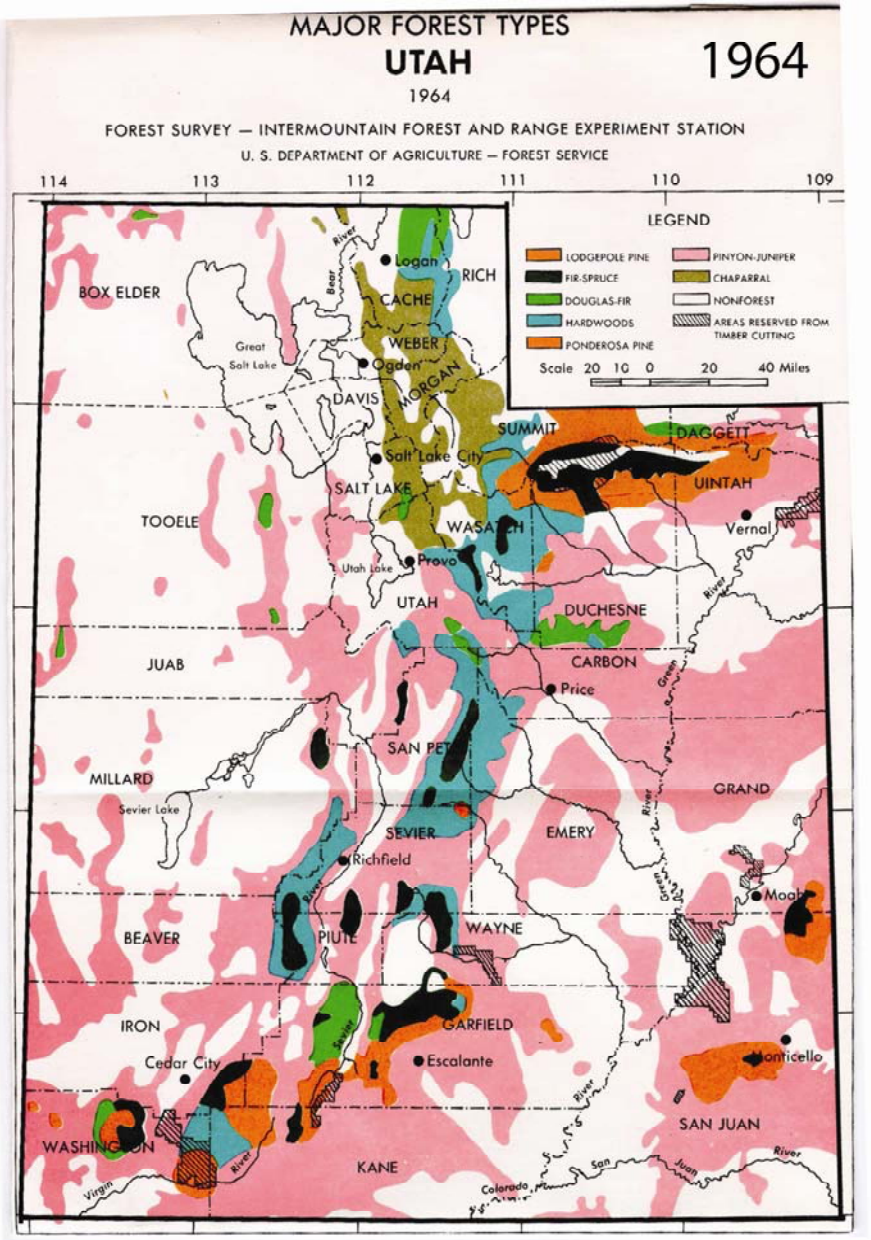
Utah's forests are extensive:

>15 million acres



Utah's forests are diverse:

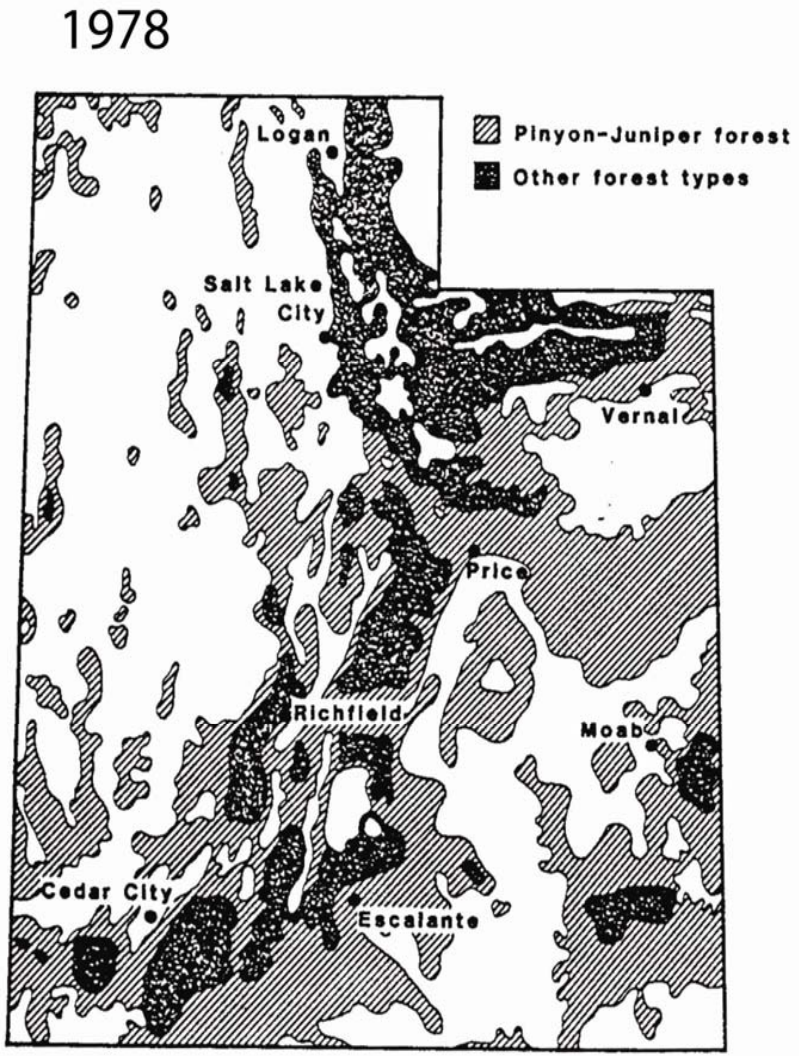
many contrasting forest ecosystems



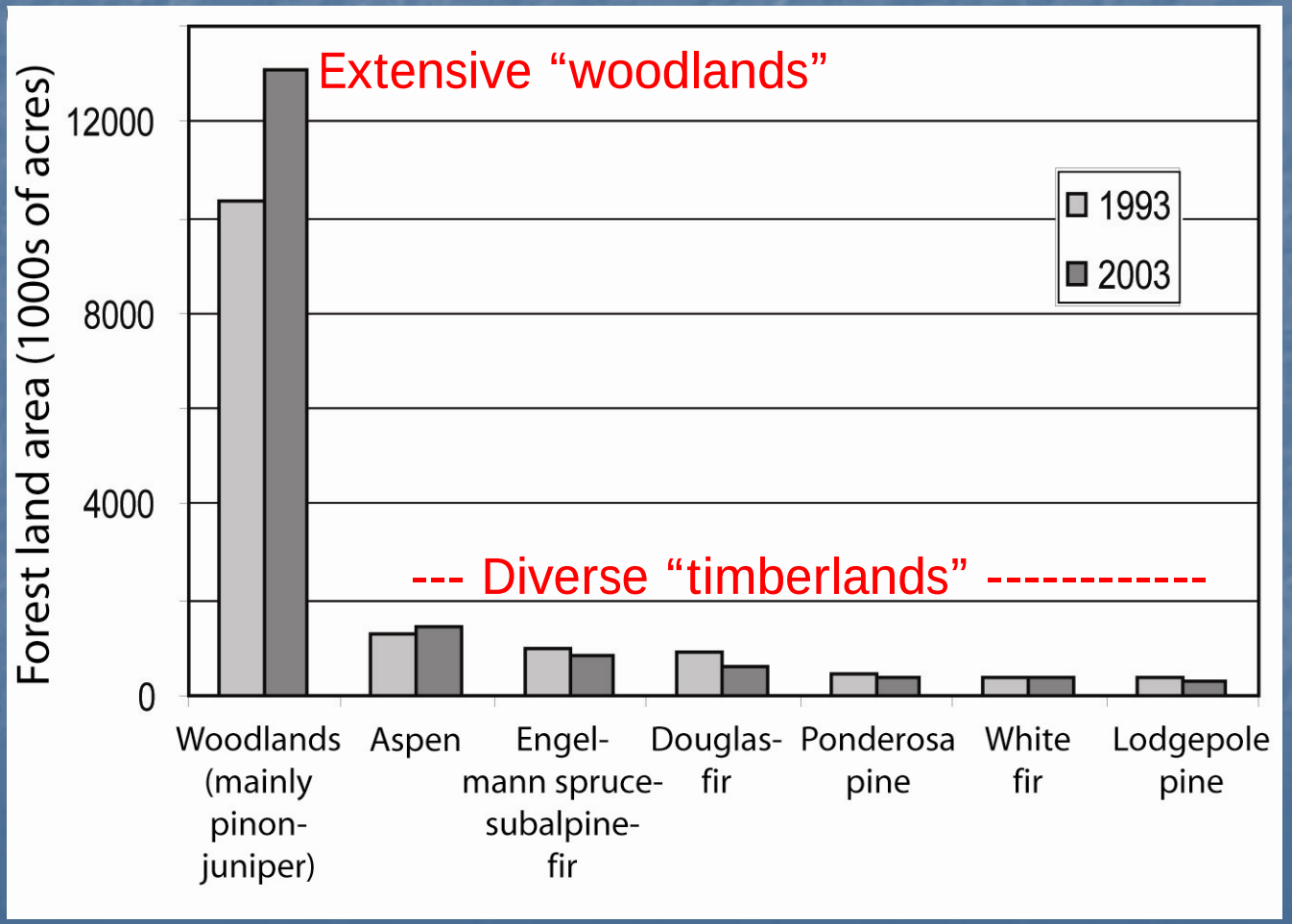
Utah's forests are dynamic:

"It is hard to imagine how dynamic Utah's forests and rangelands have been during the last 150 years.."

Major changes in area, tree species, and stand structure



Utah's forest dynamics are a tale of two forests: woodlands & timberlands



Carbon & Utah's tale of two forests

- *Woodlands:*

  Little FIA data

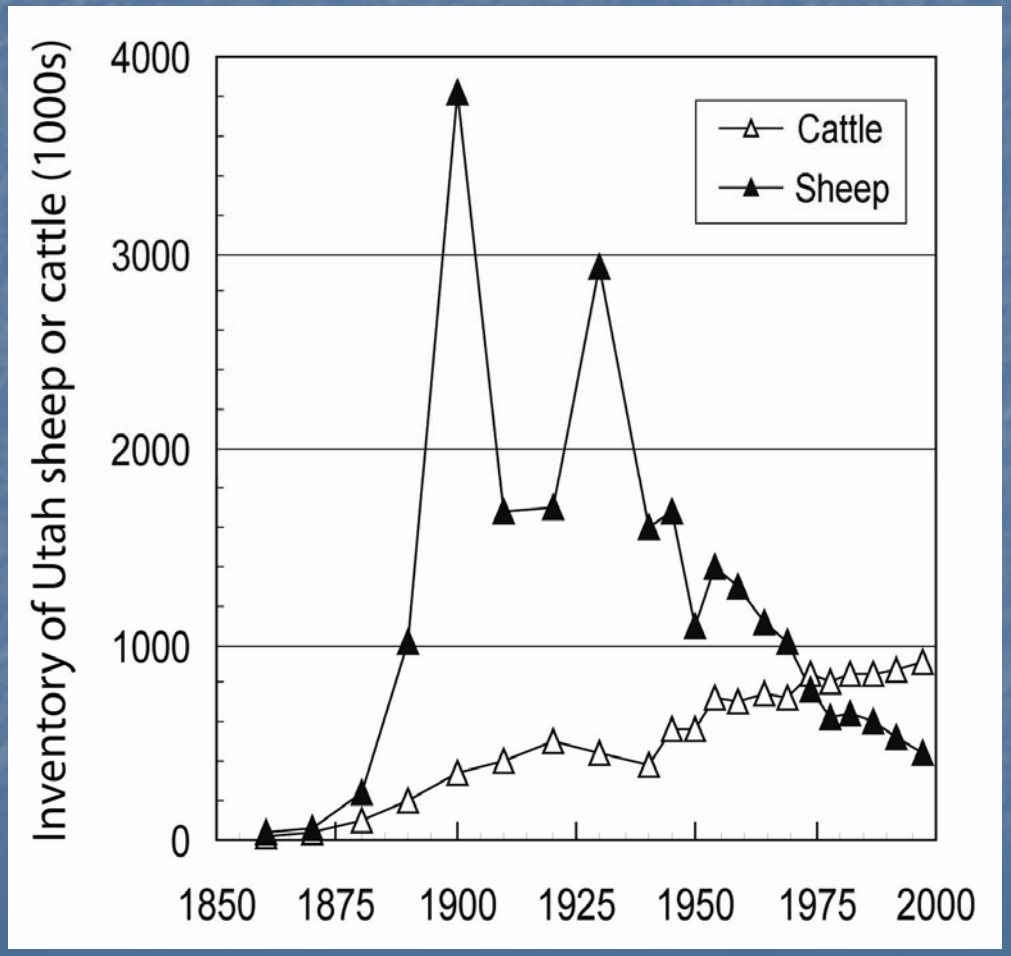
  Relatively young forests, & expanding in area but at unknown rates

- *Timberlands:*

  Uncertain FIA data

  Six contrasting ecosystems with histories of logging, pests, & disease

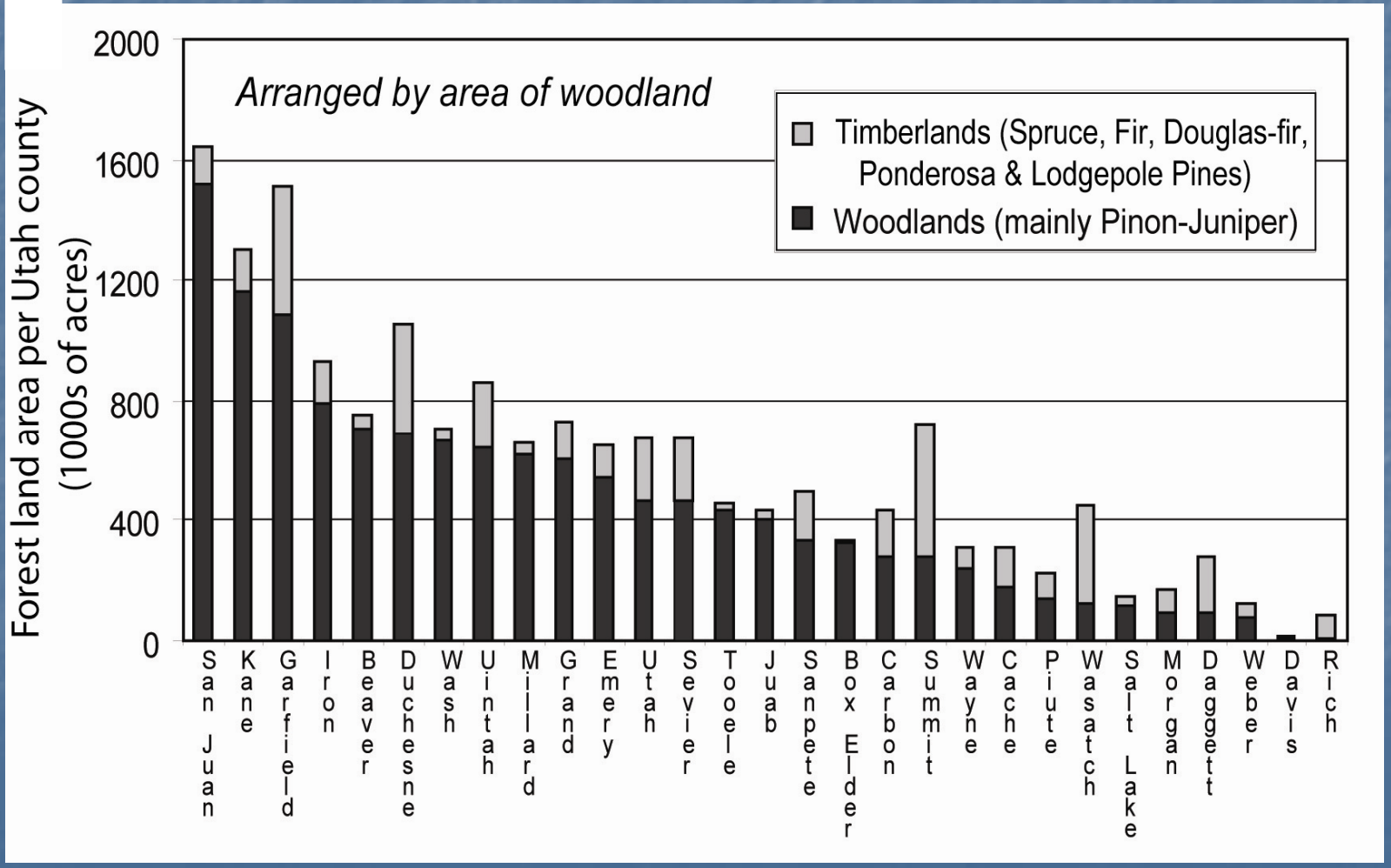
The story of Utah woodlands



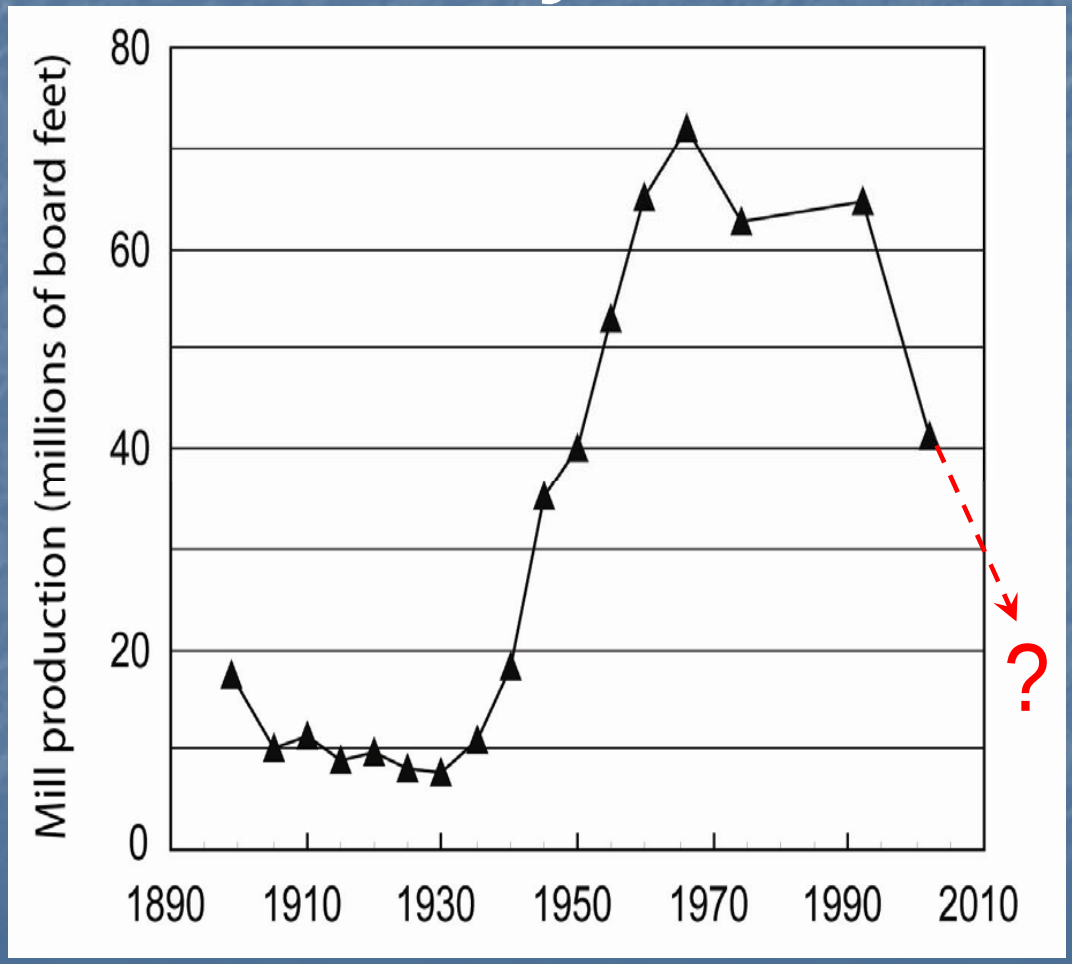
Woodlands expanding:

Grazing diminished fine fuels promoting drought-hearty woody plants in native grasslands & sagebrush

Today's woodlands, a legacy of grazing & change in fire regimes



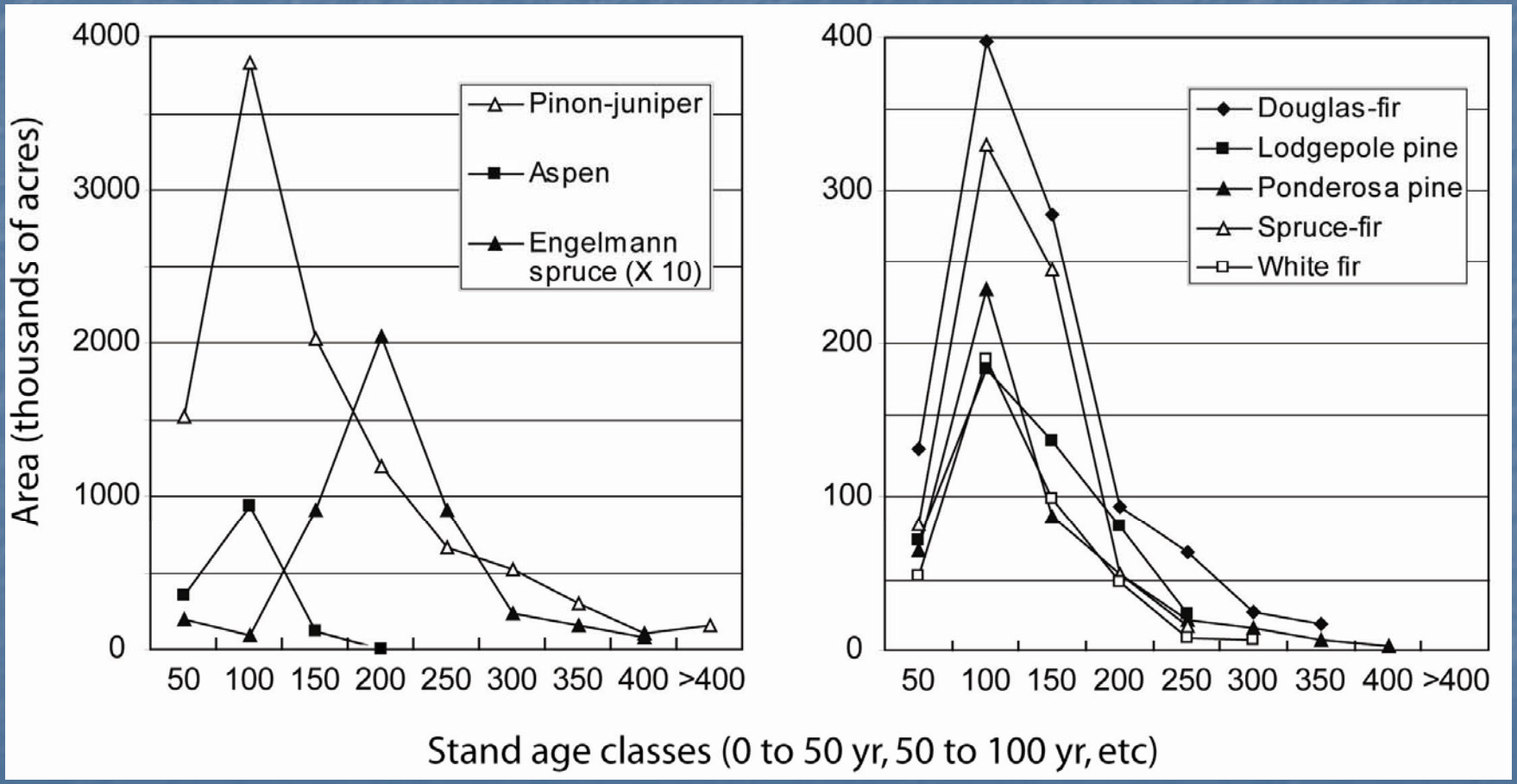
The story of Utah's timberlands



Logging peaked post-WWII with uncertain future;

Logging history left a legacy of stand regeneration

Many Utah forest stands are young, <100 yr



FIA in 1993 & 2003 concludes wood is accumulating in Utah forests

Tree species	1992	2006
	millions ft^3	
Ponderosa pine	10.7	7.4
Lodgepole pine	5.0	10.5
Engelmann spruce	13.9	11.8
Douglas-fir	20.0	4.6
True firs	- 2.7	- 4.7
Aspen	31.7	30.0
Utah total	*78.6*	*59.6*

In other words, wood is 50% carbon, & Utah forests are a carbon sink.

Earlier CCS estimates (2007) suggest carbon sink of 12 to 38 MMtons of CO_2-eq per year

- But details of reports create questions:
  - Why is forest area so high?
  - How is timberland a carbon source?
  - Is it ecologically possible for largest carbon sink to be in soil not biomass?
- An opportunity for a new approach to carbon sink

New approach: to make a series of estimates

- Rather than re-do CCS approach (re-feeding FIA data into USFS carbon models)
- We used FIA data more directly varying forest land area & sink strength per area

Woodlands carbon sink

Approach	Sink	Comments
	MMg C y^{-1}	
1. Lower bound	0.54	Increment of 0.25 MgC $ha^{-1}y^{-1}$ on 5.35 million acres <100-y old
2. Age-class		
<150-y, 1993 area	1.04	Increment of 0.35 MgC $ha^{-1}y^{-1}$ on 7.37 million acres <150-y old
<150-y, 2003 area	**1.33**	**Increment of 0.35 MgC $ha^{-1}y^{-1}$ on 9.37 million acres <150-y old**
<150-y, 2003 area	1.90	Increment of 0.5 MgC $ha^{-1}y^{-1}$ on 9.37 million acres <150-y old
3. Upper bound	2.65	Increment of 0.5 MgC $ha^{-1}y^{-1}$ on 13.1 million acres

Timberlands carbon sink

Approach	Sink MMg C y^{-1}	Comments
1. Lower bound		
2003 net ann growth	0.40	Net annual growth of 59.6 million ft^3; with 0.4 Mg m^3 and 15% root growth
2. Age-class		
1993 net ann growth	0.53	Net annual growth of 78.6 million ft^3; with 0.4 Mg m^3 and 15% root growth
<100-y, 1993 area	**1.06**	**Live tree increment (Smith et al. (2006) for 3.04 million acres of <100-y**
<150-y, 1993 area	1.32	Live tree increment from Smith et al. (2006) for 4.53 million acres <150-y
3. Upper bound	1.48	Increment of 0.75 MgC $ha^{-1}y^{-1}$ on 4.87 million acres of timberlands

Estimated Utah forest carbon sink

- 8.75 MMton y^{-1}, with upper & lower bounds of 3.4 to 15.1
- Generally lower than CCS estimates of 12 to 38 MMt y^{-1}, which CCS judged to be high

Though forest carbon sink may be lower than previous estimates, forest land sink is very important

- Carbon sinks active research area
- Carbon sink of woodlands is particularly vulnerable to loss from wildfire, conversion to grasslands, invasions of exotic grass

Returning to a story suggested earlier in talk

- Contemporary forest carbon sink owes much to land use history
- Contemporary questions involve the extent to which land management can intervene with historical forces

Important to simultaneously improve the science, management, & policy of landscape's carbon sink.

How effective can management carbon sink in the face of woodland expansion, insect and disease attacks, drought mortality, wildfire risks, and grassland restoration?